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Appendix D

6.4 Solubility

Suppose we wish to make a solution of table salt (NaCl) in water. We take some water, add a few grams of salt, and stir. At first we see the particles of salt suspended in the water, but soon all the salt dissolves. Now let us add more salt to the same solution and continue to stir. Again the salt all dissolves. Can we repeat this process indefinitely? The answer is no; there is a limit. The solubility of table salt at 25°C is 36.2 g per 100 g of water. If we add more salt than that, the excess solid does not dissolve but remains suspended as long as we keep stirring, and it sinks to the bottom after we stop.

The **solubility** of a solid in a liquid is **the maximum amount of that solid that dissolves in a given amount of liquid at a given temperature.** Solubility is a *physical constant,* like melting point or boiling point. Each solid has a different solubility in every liquid. Some solids have a very low solubility in a particular solvent. We often call these solids insoluble. Others have a much higher solubility. We call these soluble, but even for soluble solids, there is always a solubility limit. The same is true for gases dissolved in liquids.

Tables of solubility values are found in handbooks.

For solutions of liquids in liquids, however, the situation may be different. Some liquids are essentially insoluble in other liquids (gasoline in water), and others are soluble to a limit. For example, 100 g of water dissolves about 4 g of ethyl ether (another liquid). If we add more ether than that, we see two layers (Fig. 6.1). Some liquids, however, are *completely* soluble in other liquids, no matter how much is present. The most important example is ethyl alcohol and water, which form a solution no matter what quantities of each are mixed. We say that the water and ethyl alcohol are *miscible* in all proportions.

We use the word "miscible" to refer to a liquid dissolving in a liquid.

When a solvent contains all the solute it can hold at a given temperature, we call the solution **saturated.** Any solution containing a lesser amount of solute is **unsaturated.** It may seem surprising, but there are also solutions in which the solvent holds *more* solute than it can normally hold at a given temperature! Such solutions are called **supersaturated** and are fairly common (p. 182).

If, to a saturated solution at a constant temperature, an additional amount of solute is added, it does not appear that any of the additional solid will dissolve, since the solution already holds all the solute that it can. But there is actually an equilibrium here, similar to the one discussed in Section 5.9. Some particles of the additional solute will dissolve, while an equal quantity of dissolved solute will come out of solution. So, while the concentration of dissolved solute does not change, the solute particles themselves are constantly going in and out of solution.

Whether a particular solute dissolves in a particular solvent depends on several factors.

Nature of the Solute and Solvent

Here the rule is **"like dissolves like."** The more similar two compounds are, the more likely it is that one is soluble in the other. This is not an absolute rule, but it does apply in most cases.

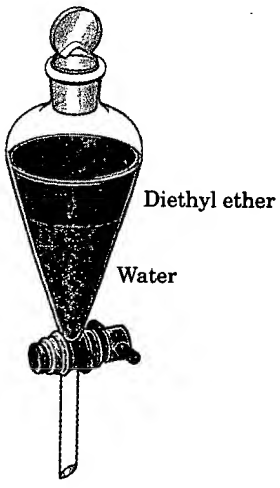

Figure **6.1**
Diethyl ether and water form two layers. A separatory funnel permits the bottom layer to be drawn off.